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An Evaluation of Air Warrior Concept Aviator Ensembles With and Without Microclimate Cooling

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The Program Manager, U.S. Army Aircrew Integrated Systems (PM-ACIS) requested that the U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, Alabama, assess the physiological and psychological effects of heat stress exposure for aviators wearing encumbered chemical defense level-4 mission oriented protective posture (MOPP4) ensembles. This project was conducted under a joint agreement between USAARL and the U.S. Army Research Institute of Environmental Medicine (USARIEM), Natick, Massachusetts. PM-ACIS recruited 10 volunteer U.S. Army helicopter pilots. Subjects were instrumented with physiological sensors and completed a 20-minute treadmill walk (3 mph, 0 percent grade) in an environmental chamber to simulate preflight activities. This was followed immediately by a simulator session consisting of two 2-hour sorties and one 1-hour sortie in the USAARL UH-60FS environmentally controlled simulator at either 100°F or 70°F (50 percent RH). We evaluated only the following five conditions: 1) ensemble A at 100°F with a microclimate cooling (MCC) water-cooled subsystem; 2) ensemble A at 70°F without MCC; 3) ensemble B at 100°F with MCC; 4) ensemble B at 100°F without MCC; and, 5) ensemble B at 70°F without MCC. The Air Warrior Concepts A and B are approximately equivalent in terms of

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their effectiveness at reducing the effects of heat stress on aviators. The addition of a microclimate cooling subsystem to the aviator ensemble appears to be substantiated as an effective method for reducing the physiological and psychological effects of heat stress. It allows the aviator in MOPP-4 clothing to conduct missions with less discomfort and greater endurance.

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Problem statement

The Program Manager, U.S. Army Aircrew Integrated Systems (PM-ACIS) requested that the U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, Alabama, assess the physiological and psychological effects of heat stress exposure for aviators wearing encumbered chemical defense level-4 mission oriented protective posture (MOPP4) ensembles. This project was conducted under a joint agreement between USAARL and the U.S. Army Research Institute of Environmental Medicine (USARIEM), Natick, Massachusetts. The methodology for assessing heat stress in an environmentally controlled helicopter simulator was established in previous studies conducted at USAARL (Reardon et al., 1996; Reardon et al., 1997; Reardon et al., 1998).

Methods

Subjects

PM-ACIS recruited 12 volunteer U.S. Army helicopter pilots. USAARL obtained full informed consent and aviators were paired as two-man crews. Each crew participated in five test sessions as outlined in the design section below. Test subjects were medically screened, and the USAARL flight surgeon eliminated two of these volunteers due to pre-existing disqualifying conditions. The final sample size was 10.

Procedures

All subjects completed a 20-minute treadmill walk (3 mph, 0 percent grade) in an environmental chamber to simulate preflight activities. The chamber temperatures used for the preflight simulation were pre-set to match the cockpit temperature being tested that day, with relative humidity (RH) during preflight set at 20 percent RH. This was followed immediately by a simulator session consisting of two 2-hour sorties and one 1-hour sortie in the USAARL UH-60FS environmentally controlled simulator at either 100°F or 70°F (50 percent RH). The sorties involved two air assaults and one medical evacuation, during which data acquisition systems collected physiological data. These sorties were separated by a 10-minute simulated hot refueling break at the 2-hour point, during which subjects were removed from the simulator and provided an opportunity to urinate. Had subjective or objective indicators suggested that test subject tolerance limits were approaching (see data collection section), the subjects would have been instructed to make a simulated landing and escorted out of the simulator to a cooling and recovery room. However, these limits were not approached in this investigation.

Test design

We evaluated two Air Warrior configurations, A and B (table 1), at 100°F and 70°F ambient cockpit temperatures (50 percent RH), with and without a microclimate cooling (MCC)

water-cooled shirt subsystem. The resulting 2×2×2 design yielded eight factors, however, because of personnel, resource, and time constraints, only five were investigated (table 2).

Table 1.
Ensemble components.

Components	Concept A	Concept B
Liquid waste collection device (diaper style)	X	X
T-shirt	X	X
Briefs	X	X
Socks	X	X
Chemical protective undergarment & socks	X	X
Combat boots	X	X
Flight suit (1 or 2-piece)	X	X
Soft body armor vest with front ballistic plate	X	X
AIRSAVE vest	X	
Extraction harness/ survival belt		X
Life preserver and HEEDS	X	X*
Communication earplugs	X	X
Chemical protective mask, hood, blower	X	X
Helmet	X	X
Chemical protective gloves, flyers gloves	X	
Seat survival pack		X**
Electronic data manager (weighted mockup)	X	X
Microclimate system***	X	X
Vapor compression cooler		
Liquid cooling shirt		

* Attached to harness
** Mounted in the simulator in the place of the standard seat cushion and contained survival items.
*** For use during both treadmill preflight simulation and flight simulation on MCC trials.

Table 2.
Conditions tested.

Condition	Ensemble	Temperature	Microclimate cooling	Tested
1	A	70	Yes	
2	A	70	No	✔
3	A	100	Yes	✔
4	A	100	No	
5	B	70	Yes	
6	B	70	No	✔
7	B	100	Yes	✔
8	B	100	No	✔

Data collection

Objective physiological data

Instrumentation was applied to record physiological parameters: heart rates, core temperatures, and skin temperatures. Heart rates were recorded with a three lead system using Ver-Med electrodes positioned to maximize R-wave tracing and were monitored every 5 minutes to ensure adherence to physiological limits (not to exceed 90 percent of age-adjusted predicted maximums). Core temperatures were measured with self-inserted, pre-calibrated YSI 401 rectal thermistors, and were monitored every 5 minutes to ensure adherence to physiological limits (not to exceed 102.56°F). Additionally, dehydration and perspiration were determined by comparing pre- and post-study total undressed and dressed weights. Fluid intake and voided urine weights also were recorded.

Subjective psychological data

Subjective data were measured with a mood and symptoms questionnaire (see appendix) administered prior to the simulated preflight and every 2 hours after the subjects began the treadmill session. Using a 10-point Likert-type scale, volunteers assessed their sensation of: headache, nausea, stress, anger, depression, energy, heat stress, thirst, workload, boredom, dizziness, and visual difficulty. Hot spot (pressure point discomfort) locations and intensities also were reported. In addition, subjects provided written feedback about ensemble components and overall satisfaction levels with each configuration at the end of each test session.

Analyses

The unbalanced design prescribed the available analyses (table 3). Thus limited, we tested several hypotheses to draw meaningful conclusions from the serviceable data. The first analysis, hereafter referred to as "Analysis 1," compared conditions 2, 3, 6 and 7. This allowed us to test two hypotheses: first, that objective physiological measures on both ensembles A and B were equal (H_0, A = B) and second, that the ensembles with microclimate cooling in a 100°F ambient temperature environment were equivalent to the ensembles without microclimate cooling in a 70°F ambient temperature environment (H_0, 100°F w/MCC = 70°F w/o MCC). The second analysis, hereafter referred to as "Analysis 2," compared conditions 6, 7 and 8. This allowed us to use the 70 degree environment as baseline (within ensemble B only) and analyze the effects of microclimate cooling in a 100 degree ambient temperature environment (H_0, B 70°F w/o MCC = B 100°F w/MCC = B 100°F w/o MCC).

Table 3.
Analysis conditions.

Condition	Ensemble	Temperature	Microclimate cooling	Analysis 1	Analysis 2
1	A	70	Yes		
2	A	70	No	✔	
3	A	100	Yes	✔	
4	A	100	No		
5	B	70	Yes		
6	B	70	No	✔	✔
7	B	100	Yes	✔	✔
8	B	100	No		✔

The data were subjected to repeated measures multiple analysis of variance (MANOVA) to test for significant main effects and higher order interactions. Analysis 1 was a 2(ensemble) x 2(condition) within subjects design with three repeated measures: endurance (defined as the interval from starting the simulated preflight to completion of the simulator session), core temperature, and heart rate. Analysis 2 had three levels (condition) with three repeated measures: endurance, core temperature, and heart rate. Tukey Honestly Significant Difference (HSD) post hoc tests were used to analyze significant pairwise comparisons.

For each test session, total amounts of sweat, sweat rates, amount of sweat evaporated, and amount retained in the uniform were determined. Sweat loss estimate was obtained from the term: $(\text{weight}_{\text{initial nude}} - \text{weight}_{\text{post nude}}) + (\text{weight}_{\text{water}} + \text{weight}_{\text{food}} - \text{weight}_{\text{urine}})$. Total sweat loss minus evaporated sweat permitted an assessment of the amount of sweat retained in the ensemble. Dehydration was calculated by using the formula: $100[(\text{weight}_{\text{sweat loss}} + \text{weight}_{\text{urine output}} - \text{weight}_{\text{water}})/ \text{weight}_{\text{initial nude}}]$. Dehydration rates were calculated for each analysis from the fluid intake/output data using the formula: $(\text{total sweat loss}_{(\text{ml})} + \text{urine output}_{(\text{ml})} - \text{fluid intake}_{(\text{ml})})/ \text{endurance}_{(\text{hours})}$. MANOVAs as described previously were used to test for significant effects in the calculated data.

Subjective data reports of mood, symptoms, and hot spots were subjected to MANOVAs where appropriate. Otherwise, categorical and frequency data were analyzed with non-parametric techniques and Lawshe-Baker Nomographs (Downie and Heath, 1965).

Results

Physiological data

Analysis 1

Due to illness, Subject 6 did not participate in the test condition that entailed wearing ensemble A with MCC at 100°F. A mean substitution technique was used to minimize data loss resulting from this missing data point.

The results of the MANOVA for Analysis 1 revealed that objective physiological measures for both ensembles were equal [Rao R[1] (3,7) = 1.47; $p<0.3022$]. Likewise, the interaction between ensemble and condition was not significant [Rao R (3,7) = 0.22; $p<0.8787$]. However, there was a significant main effect for condition (figure 1). That is, for both ensembles, measures were not the same for both 70°F ambient temperature without MCC and 100°F ambient temperature with MCC [Rao R (3,7) = 10.47; $p<0.0056$]. Tukey HSD analyses showed that mean endurance was significantly lower at 100°F ambient temperature with MCC and mean core temperatures were significantly higher ($p<0.003$). Mean heart rate did not differ significantly between the two conditions ($p<0.189$).

Analysis 2

The MANOVA for Analysis 2 revealed that the main effect for condition (within ensemble B only) was significant [Rao R (6,4) = 52.96; $p<0.0009$] (figure 2). Tukey HSD analyses showed that mean endurance was significantly shorter at 100°F ambient temperature without MCC than both 70°F ambient temperature without MCC and 100°F ambient temperature with MCC ($p<0.0002$). The latter were not significantly different from each other ($p>0.05$). Likewise, heart rate was significantly higher at 100°F ambient temperature without MCC than both 70°F ambient temperature without MCC and 100°F ambient temperature with MCC ($p<0.0002$), and the latter were not significantly different from each other ($p>0.05$). Core temperatures, on the other hand, were higher for both the 100°F ambient temperature conditions as compared to the 70°F ambient temperature condition ($p<0.018$). Additionally, the 100°F ambient temperature condition core temperatures were significantly different from each other ($p<0.0002$).

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[1] Statistica's MANOVA module reports Rao R, a transformation of Wilks lambda that follows an F distribution exactly, which is used to determine the significance of the given effects .

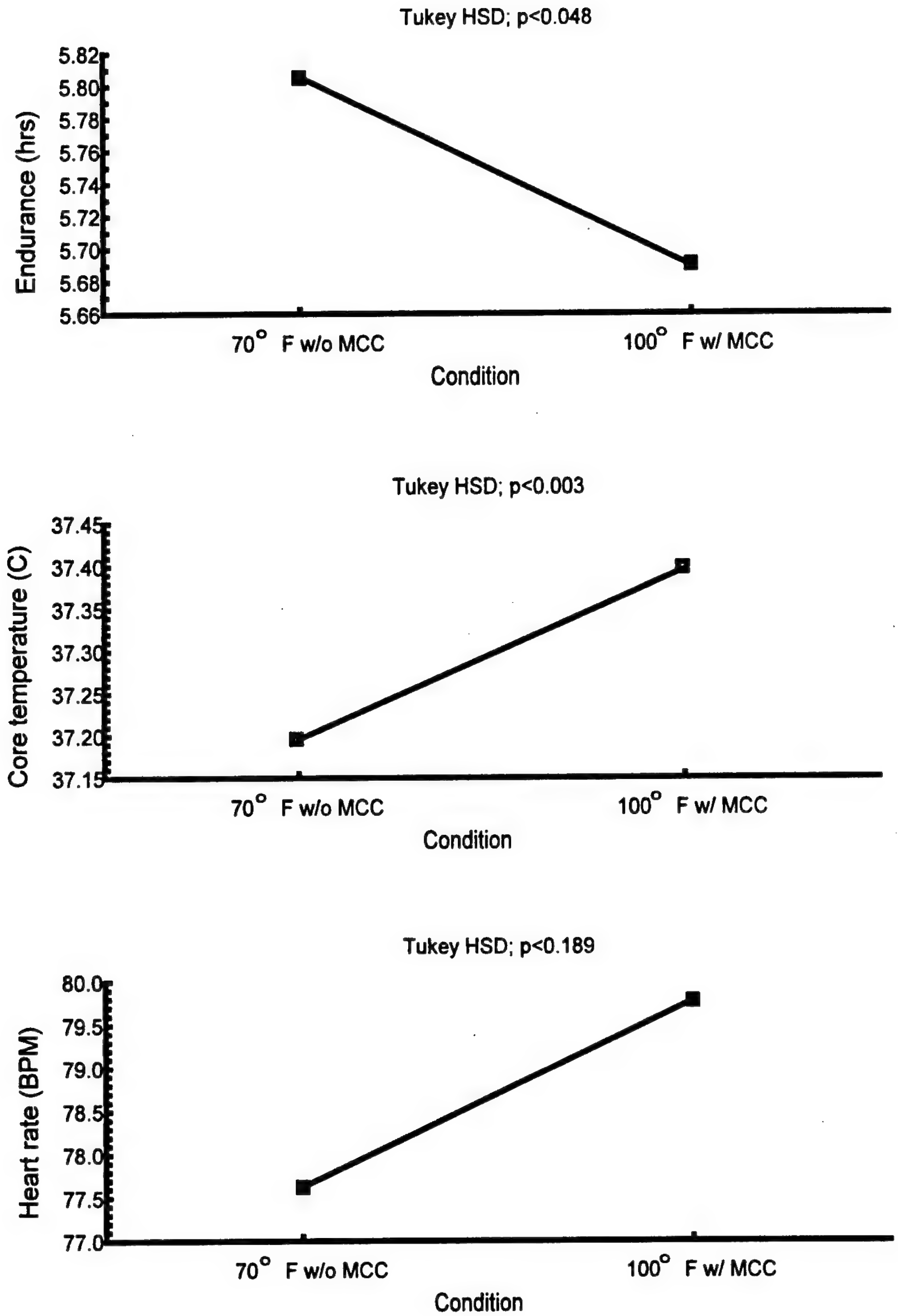


Figure 1. Condition main effect for each objective physiological measure in Analysis 1 [Rao R (3,7) = 10.47; p<0.0056].

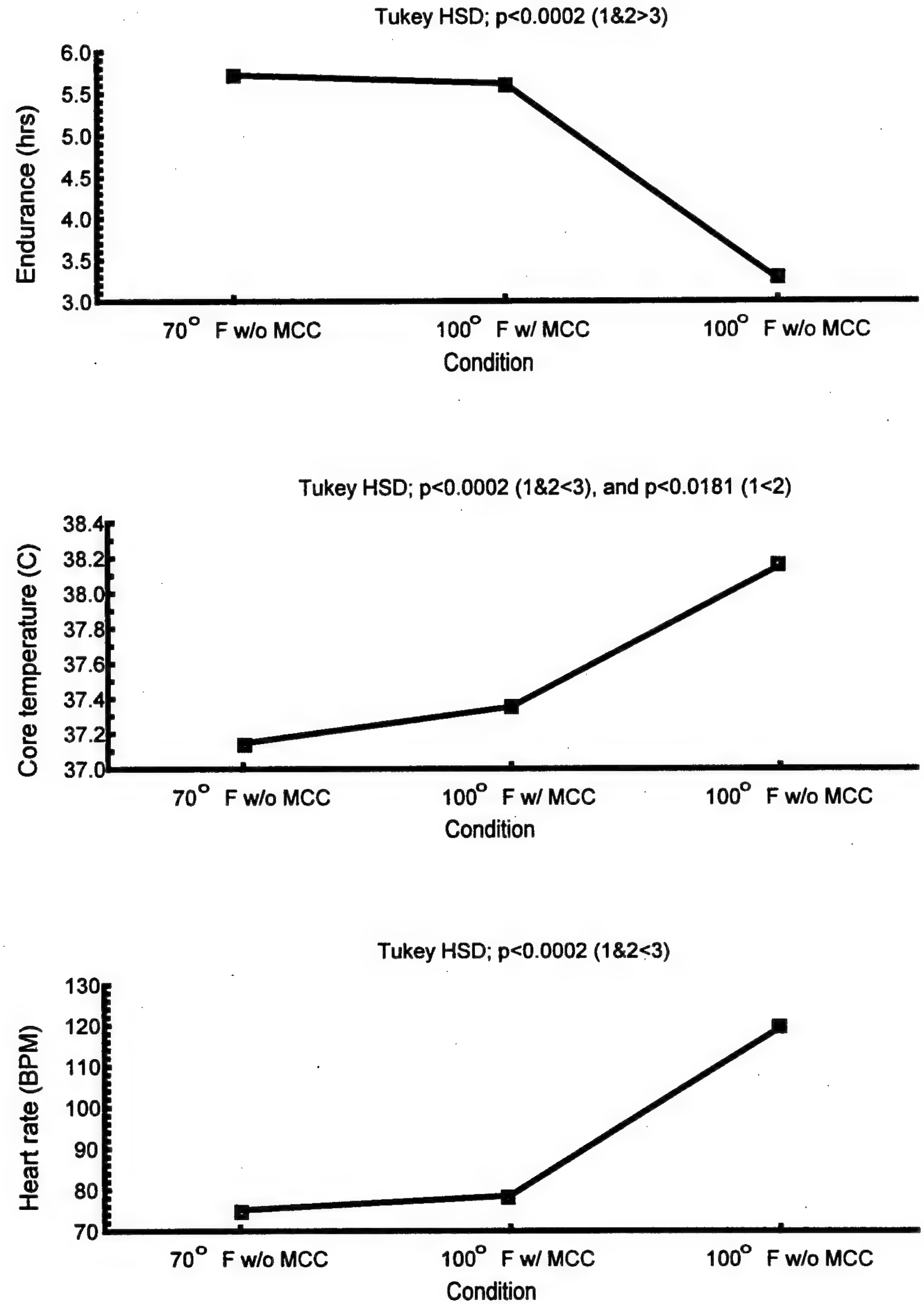


Figure 2. Condition main effect for each objective physiological measure in Analysis 2 [Rao R (6, 4) = 52.96; p<0.0009].

Fluid gain and loss

Dehydration rates were calculated for each analysis from the fluid intake/output data. The data for Analysis 1 showed that dehydration rates using an MCC system at 100°F ambient temperature were not significantly different from rates at 70°F ambient temperature without an MCC system (figure 3). The ANOVA on these data showed that for Analysis 1, main effects of ensemble and condition on dehydration rates were not significant [$F(1, 9)=2.80$, $p<0.1286$ and $F(1, 9)=0.57$, $p<0.471$, respectively]. Similarly, the interaction between ensemble and condition was not significant [$F(1, 9)= 0.410$, $p<0.5380$]. In Analysis 2, the ANOVA showed a significant main effect for condition [$F(2, 18)=12.81$, $p<0.0003$] (figure 4). The Tukey HSD test revealed that this was due to significantly higher dehydration rates in the 100°F condition without MCC as compared to the other two conditions (i.e., 1&2< 3; $p<0.002$).

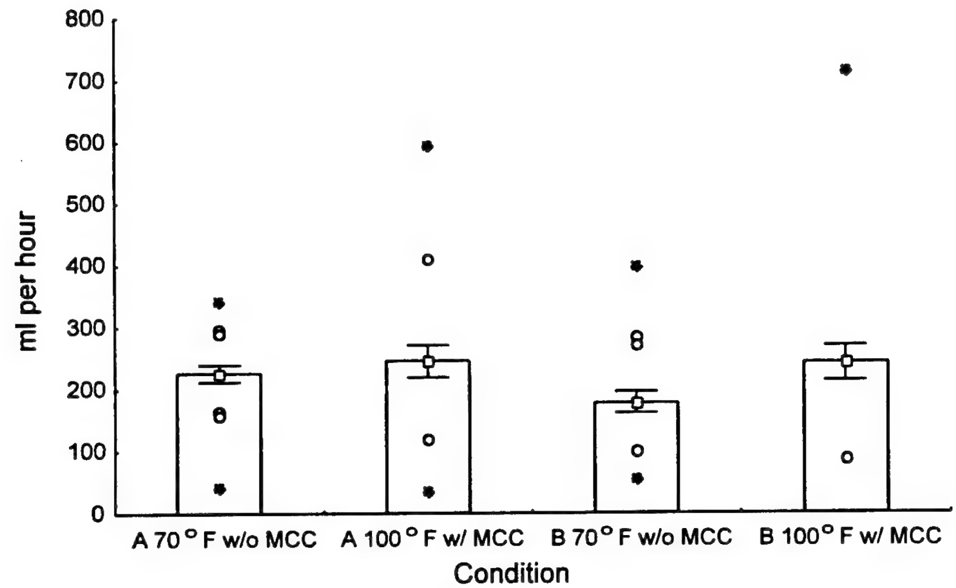


Figure 3. Dehydration rates (Analysis 1). ± 1 standard error (SE) from mean; o = outlier scores beyond 1.96 SE but less than 6 SE from the mean; * = extreme scores beyond 6 SE from the mean. Graphic representations allow quick conservative judgements of the significance of differences between means without computations or extensive tables. In general, when the standard error bars overlap, the means do not differ significantly (dependent on sample n) at the .05 level (Dunlap and May, 1988).

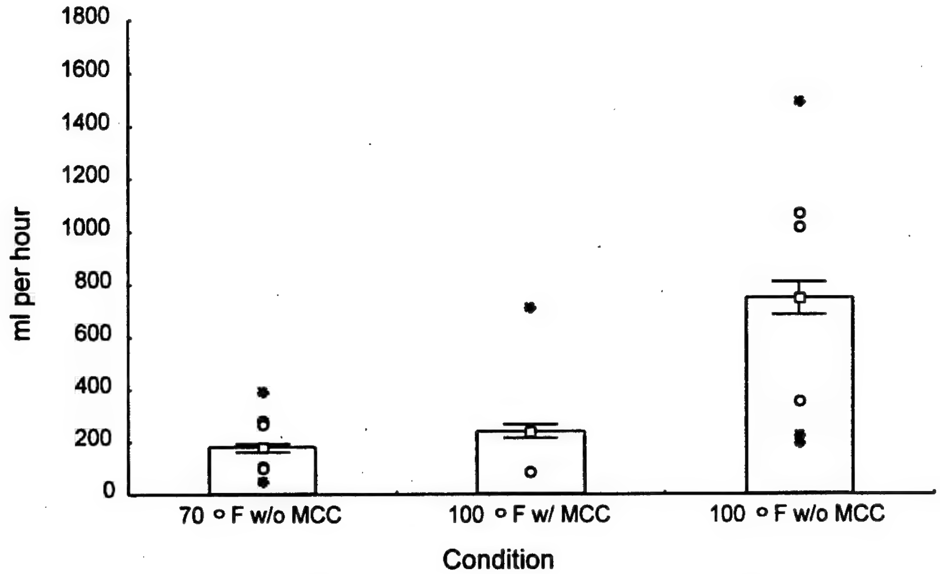


Figure 4. Dehydration rates (Analysis 2).

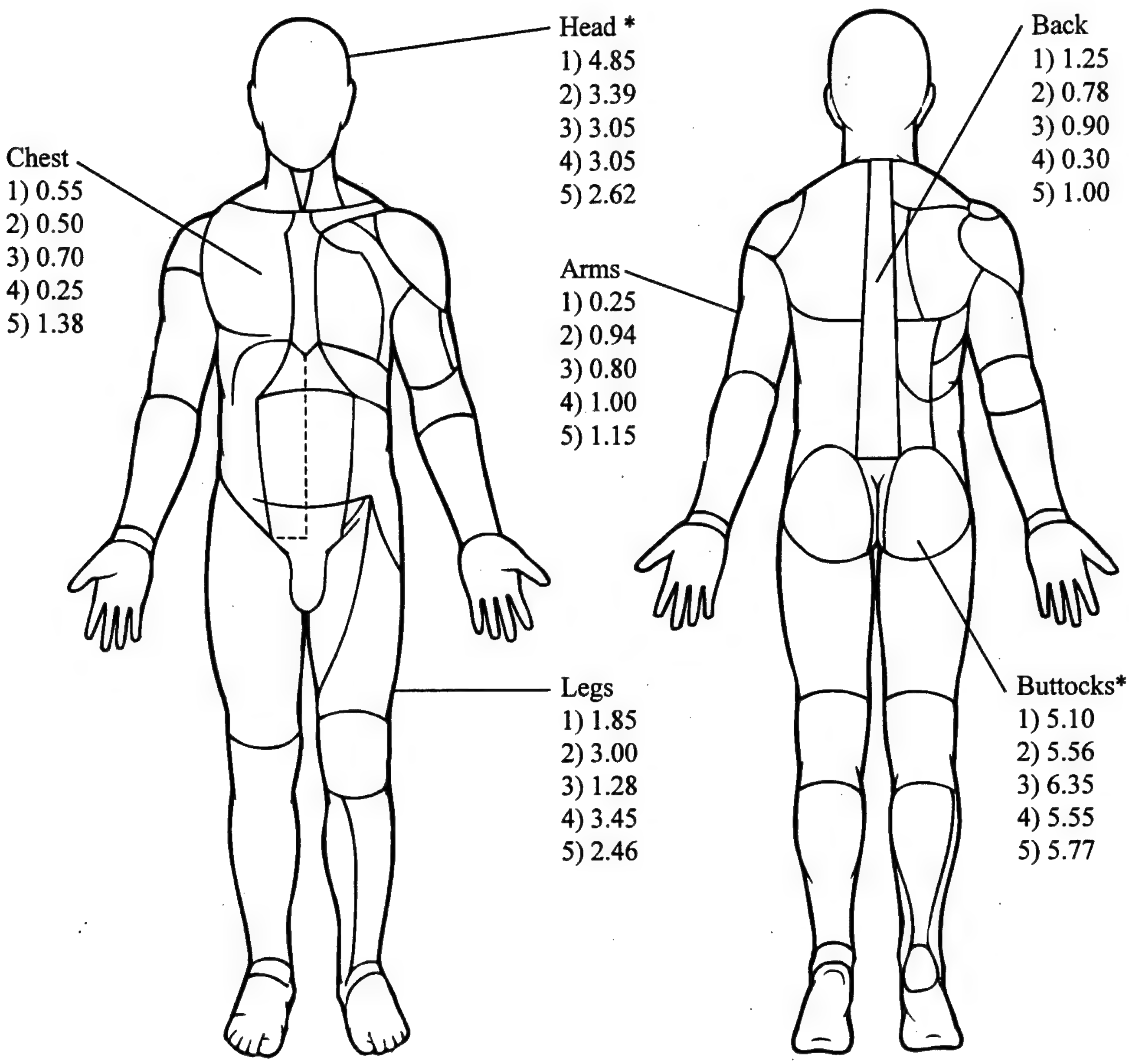
Subjective data

Subjective ratings of mood and symptoms are shown below (table 4). Ratings ranged on a Likert-type scale from 0 (none) to 10 (a lot). For ease of computation and interpretation, energy scores were subtracted from 10. Once transformed, lower scores were better for all items. These data were subjected to analyses 1 and 2. We added a factor for symptom/mood, which had 12 levels. These were not separate repeated measures, but rather items within a questionnaire. Thus, for analysis 1, a 2(ensemble) × 2(condition) × 12(measure) analysis of variance (ANOVA) was performed and showed there were no significant differences in mood/symptoms between ensemble or condition [$F(1,9)= 1.166$; $p<0.3083$ and $F(1,9)= 0.007$; $p<0.94$, respectively]. Likewise, all interactions were nonsignificant ($p>0.05$). In contrast, the main effect for measure was significant [$F(11,99)= 15.86$; $p<0.0001$] and the Tukey HSD test showed numerous significant differences ($p<0.05$). In general, data were highest (worst) for energy, boredom, and visual difficulty. Items with the lowest ratings (fewest symptoms) were nausea, anger, depression, and dizziness. For analysis 2, a 3(condition) × 12(measure) ANOVA showed significant main effects for condition and measure [$F(2,18)= 30.706$; $p<0.0001$ and $F(11,99)= 12.577$; $p<0.0001$, respectively]. Additionally, the interaction between condition and measure was significant [$F(22,198)= 6.211$; $p<0.0001$]. Tukey HSD tests showed these results were based on significant elevations in nausea, stress, anger, energy, heat stress, thirst, workload and dizziness in the 100°F condition without MCC ($p<0.05$). Reported symptoms for headache, depression, boredom, and visual difficulty were not significantly different in this worst case condition.

Table 4.
Mood and symptoms questionnaire (lower is better).

	A 70°F w/o MCC	A 100°F w/ MCC	B 70°F w/o MCC	B 100°F w/ MCC	B 100°F w/o MCC
Headache	1.33	1.33	1.33	0.97	1.35
Nausea	0.37	0.07	0.00	0.10	1.26
Stress	0.87	1.07	0.87	0.57	2.52
Anger	0.03	0.26	0.07	0.00	0.87
Depression	0.00	0.00	0.00	0.00	0.22
Energy (10-score)	3.00	2.85	2.77	2.53	4.17
Heat stress	0.70	1.37	0.73	1.07	4.43
Thirst	2.27	1.30	1.77	1.70	3.39
Workload	1.87	1.89	1.77	1.80	3.22
Boredom	3.33	3.15	2.73	3.17	2.91
Dizziness	0.07	0.04	0.00	0.00	1.74
Visual difficulty	4.33	4.22	4.73	4.50	4.91

Hot spot intensity ratings for each of the five conditions are shown in figure 5 . These data were subjected to analyses similar to the previously reported mood/symptom ANOVAs except a factor for hot spot intensity location replaced the factor for measure. Thus, for analysis 1, a 2(ensemble) × 2(condition) × 6(location) ANOVA was performed and showed there were no significant differences between reported hot spot intensities for ensemble or condition main effects [$F(1,9)= 1.996$; $p<0.1913$ and $F(1,9)= 0.621$; $p<0.45$, respectively]. Likewise, all interactions were nonsignificant ($p>0.05$). However, the main effect for location was significant [$F(5,45)= 22.23$; $p<0.0001$] and the Tukey HSD test showed that as compared to all other hot spots, the most intense hot spots were reported for the head and buttocks ($p<0.0016$). Intensity ratings for head and buttocks were not significantly different from each other ($p<0.0650$). For analysis 2, a (2 condition) × 6(location) ANOVA showed the same results. Differences between reported hotspot intensities for the condition main effect were not significant [$F(2,18)= 5.2815$; $p<0.0001$], and the interaction between condition and location was nonsignificant [$F(10,90)= 2.049$; $p<0.5641$]. The main effect for location was again significant [$F(5,45)= 19.599$; $p<0.0001$] and likewise, the Tukey HSD test again showed as compared to other hot spot areas, the most intense hotspots were reported for the head ($p<0.044$) and buttocks ($p<0.001$). However, in this analysis, intensities associated with the head and buttocks were significantly different from each other, with buttock hot spots being rated significantly higher ($p<0.001$).



* significant differences between these hotspots as compared to all other areas ($p<0.05$).

Figure 5. Mean hot spot ratings by ensemble on a scale of 0 (none) to 10 (extreme). 1) Ensemble A, 70°F without MCC; 2) Ensemble A, 100°F with MCC; 3) Ensemble B, 70°F without MCC; 4) Ensemble B, 100°F with MCC; and 5) Ensemble B, 100°F without MCC.

"Other" hot spots indicated by respondents are presented in figure 6. The Lawshe-Baker Nomograph indicated that within both ensembles A and B, hot spots were reported with significant frequency on the nose and feet [$\omega = 0.7046$; $p < 0.05$]. All other contrasts were nonsignificant [$p > 0.05$]. Hot spots associated only with ensemble A consisted of the hands (7 percent), whereas those associated only with ensemble B consisted of the neck (4 percent) and face (4 percent). However, no pairwise contrasts between ensembles were significantly different [$\omega = 0.4660$; $p > 0.05$].

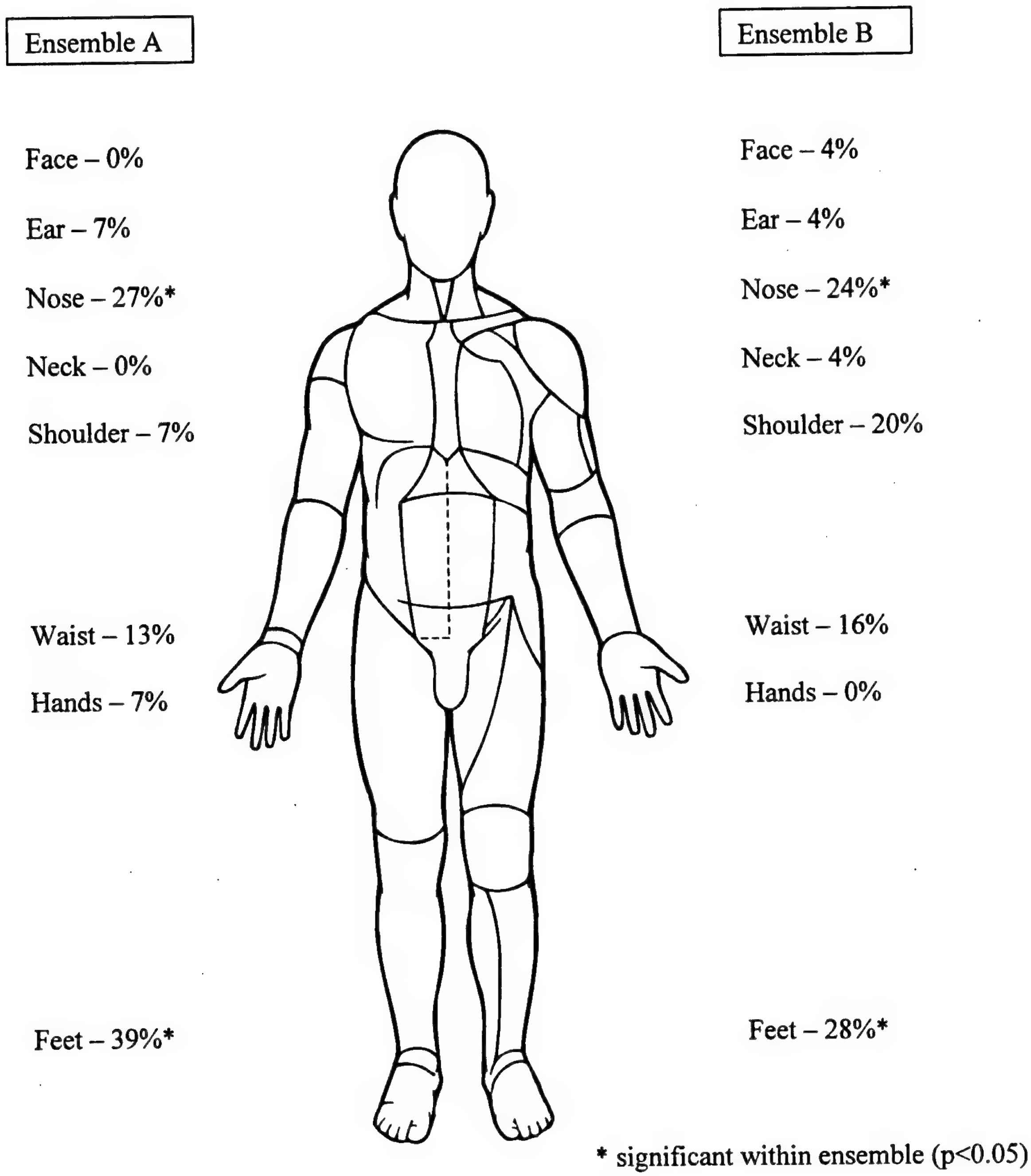


Figure 6. Percentages of "other" hot spots reported partitioned by ensemble.

All objective and subjective results were rank ordered for each ensemble, without being weighted as to their relative practical importance, with 1 being best and 5 being worst (table 5). Based upon the unweighted rankings, a Friedman ANOVA for the five conditions showed a significant main effect for condition [ANOVA $x^2_{(4)} = 18.54$; $p < 0.001$] and inspection of the means revealed that ensemble B without MCC in the 100°F condition was significantly worse than the other four conditions ($p<0.05$) (figure 7). Based on unweighted ranks, the remaining four conditions were not significantly different from each other.

Table 5.
Ranking of measures.

	A 70°F w/o MCC	A 100°F w/ MCC	B 70°F w/o MCC	B 100°F w/ MCC	B 100°F w/o MCC
Physiological data rankings					
Endurance (hours)	1	2	3	4	5
End pre-flight HR (bpm)	5	4	2	1	3
End simulator HR (bpm)	1	4	2	3	5
Core temp (simulated pre-flight)	4	3	2	1	2
Core temp (UH-60 simulator)	1	4	2	3	5
Questionnaire data rankings					
Headache	2	2	2	1	3
Nausea	4	2	1	3	5
Stress	2	3	2	1	4
Anger	2	4	3	1	5
Depression	1	1	1	1	2
Energy	1	2	3	4	5
Heat stress	1	4	2	3	5
Thirst	4	1	3	2	5
Workload	3	4	1	2	5
Boredom	5	3	1	4	2
Dizziness	3	2	1	1	4
Visual difficulty	2	1	4	3	5
Hot spot data rankings					
Head	5	3	4	2	1
Chest	4	2	3	1	5
Back	4	3	2	1	3
Buttocks	2	4	5	3	1
Arm	3	1	2	2	4
Leg	1	3	2	5	4
Other	3	4	1	5	2
Average	2.67	2.75	2.25	2.38	3.75

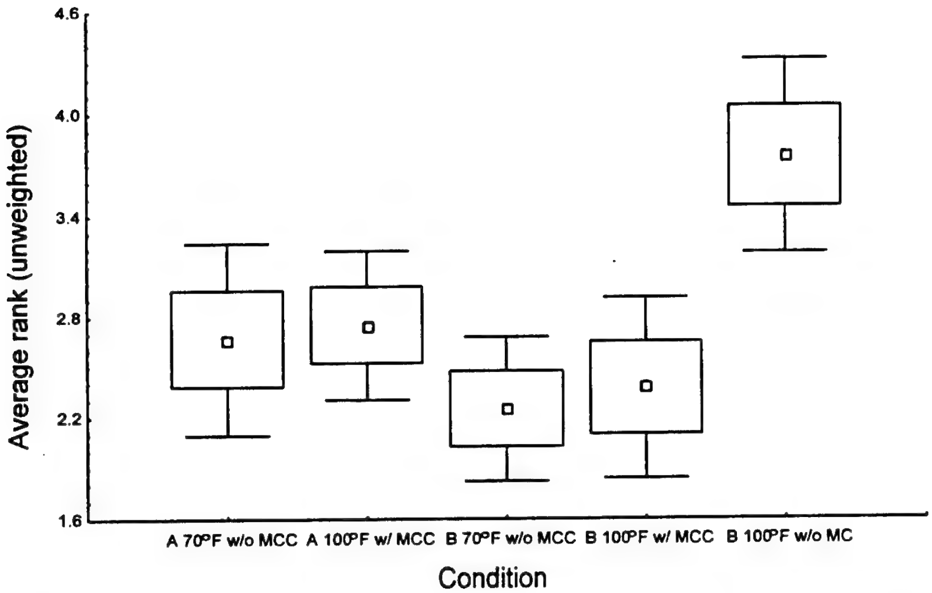


Figure 7. Mean unweighted rankings of dependent measures. Center box = mean; outer box = ±1 SE around the mean; whiskers = ± 1.96 SE from mean.

Frequencies of positive and negative written comments pertaining to each ensemble are presented in tables 6 and 7. The predominant complaints involved the bulkiness of the configurations and the pressure on the bridge of the nose and forehead caused by the mask.

Table 6.
Frequency of negative responses.

Negative comments	A 70°F w/o MCC	A 100°F w/ MCC	B 70°F w/o MCC	B 100°F w/ MCC	B 100°F w/o MCC
Pressure bridge of nose	7	6	6	9	3
Rubs forehead	3	1	2	2	2
Poor visibility	4	2	2	3	3
Restricted head movement	3	3	1	3	4
Overall bulky, hard to move	8	6	9	4	4
Floatations inhibit movement	4	1	1	1	2
Diapers uncomfortable caused rash	1	0	1	0	0
Blower fit and in the way of cyclic	3	3	2	0	3
Gloves inhibit dexterity	0	1	1	3	1
Belt interferes with collective	0	1	1	1	2
Radio in the way of collective	0	0	2	2	2
MCC suit too cold	n/a	1	n/a	2	n/a
Not practical for a real mission	4	2	2	1	3
Waist band rubbed skin	1	0	0	1	1
Pressure on ears	1	0	0	0	0
Ensemble is heavy to wear	4	2	2	2	2
Ballistic plate unsecured, rubs	0	1	2	0	0
Communication problems	0	0	0	1	1
Socks didn't fit well	1	0	0	0	1

Table 7.
Frequency of positive responses.

Positive comments	A 70°F w/o MCC	A 100°F w/ MCC	B 70°F w/o MCC	B 100°F w/ MCC	B 100°F w/o MCC
MCC shirt great	N/a	5	n/a	6	n/a
Chemical suit good	0	0	0	1	0
Ear plugs great	1	1	1	1	1
Like mask	1	0	0	0	1
Helmet fits well	2	1	1	1	0
Like blower	1	1	0	0	0

Finally, test subjects were asked to rate their overall level of satisfaction with each ensemble following each test session by assigning a letter grade to the configuration (table 8). For ease of computation, we converted the letter grades to numerical values to determine the average ratings. The B ensemble with MCC at 100°F was rated highest, with a mean rating in the C+ range.

Table 8.
Overall satisfaction.

Subject	A 70°F w/o MCC	A 100°F w/ MCC	B 70°F w/o MCC	B 100°F w/ MCC	B 100°F w/o MCC
1	C+	B	B	B	F
2	F	D	D	C	F
3	F	C	C	C	C
4	C+	B	C	B	C
5	B	C+	B	B	B
6	C+	C+	C-	C	D
7	B+	F	F	D	F
8	F	C	C	C	D
9	D	D	D	B	D
10	B	D	D	D	D
Average	C-	C-	C-	C+	D

Discussion

Based upon the objective data, it appears that microclimate cooling significantly reduces the effects of heat stress on aviators. The 100°F ambient temperature condition (50 percent RH) without MCC represented the worst case scenario in this study. Our analyses of ensemble B showed that, in a 100°F ambient temperature condition with MCC, physiological measures were not significantly different from the 70°F ambient temperature condition without MCC. Both of these differed significantly from the worst case scenario. However, MCC is not a panacea. When the variance from the worst case scenario was excluded (i.e., as in Analysis 1), then the 100°F MCC condition measures were significantly different from the 70°F conditions without MCC. The practical significance of these differences should be considered given the apparently

arbitrary levels of the test (i.e. would these differences have been significant if 75°F was chosen for the "cool" environment?). Notwithstanding, the Air Warrior Concepts A and B are approximately equivalent in terms of their effectiveness at reducing the effects of heat stress on aviators.

Subjectively, the Air Warrior Concept B chemical protective ensemble with MCC appears to be the most preferred of the two configurations compared in this study in a hot environment. Albeit, the test subjects complained that both ensembles were too bulky, making movement difficult, and that the mask created pressure on the bridge of the nose and forehead. Despite the fact that each test subject was individually fitted with a mask and helmet by subject matter experts, mask-induced pressures on the bridge of the nose and forehead were consistent irritants to the test subjects, and were documented photographically throughout testing. These photographs have been provided to PM-ACIS. The lower frequency of complaints in this area in the ensemble B without MCC at 100°F condition is likely to be a byproduct of the shorter endurance times in that environmental condition.

In sum, the addition of a microclimate cooling subsystem to the aviator ensemble appears to be substantiated as an effective method for reducing the physiological and psychological effects of heat stress. It allows the aviator in MOPP-4 clothing to conduct missions with less discomfort and greater endurance. However, subjects reported dissatisfaction related to the mask, which they believed would decrease their effectiveness in extended operations and which should be addressed in the interest of improving the practicality and user acceptance of the Air Warrior ensembles.

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Appendix.

Mood and symptoms questionnaire

HEAT STRESS 98 - MOOD AND SYMPTOMS QUESTIONNAIRE
v 4/10/98

Today's Date:__________ Test Subject No. ____

❑ Instructions:
1. Administer the series of questions at the following times: Just prior to simulated pre-flight and at times indicated in flight profile.
2. Alert the test subject with the following :"Test subjects name, Mood and symptoms questionnaire "
3. Go through the questions using the same pace, wording, and inflection for each administration.
4. Record results in appropriate locations.

	QUESTION	SCALE	(Treadmill)	RATINGS										
	On a scale of 0 to 10 with respect to the past 5-10 min please rate your sensation of:	Timer Time (Hrs:mins)--->												
1	headache	(0 = none 10 = very severe)												
2	nausea	(0 = none 10 = about to vomit)												
3	stress	(0 = none 10 = very severe, can't take it)												
4	anger	(0 = none 10 = extremely)												
5	depression	(0 = none 10 = extremely)												
6	energy	(0 = none 10 = a lot)												
7	heat stress	(0 = none 10 = unbearable)												
8	thirst	(0 = none 10 = severe)												
9	workload	(0 = very light 10 = overwhelming)												
10	boredom	(0 = none 10 = totally boring)												
11	dizziness	(0 = none 10 = very severe)												
12	visual difficulty	(0 = none 10 = can hardly see)												
13	hot spots (0 = none 10 = a lot) location:	a) head b) chest c) back d) buttocks e) arm f) leg g) other												
		Technician initials --->												

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